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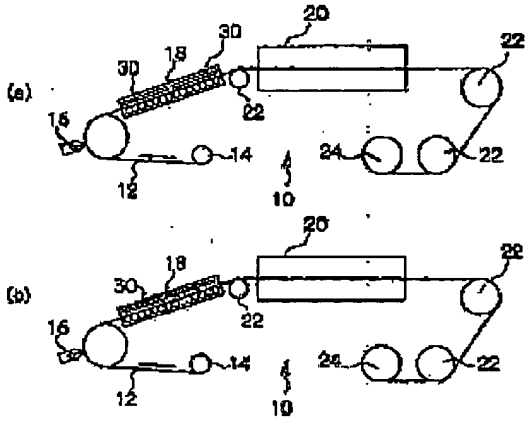
[Note: All names, addresses, company names, and brand names are translated in the most common manner. Japanese language does not have singular or plural words unless otherwise specified with numeral prefix or general form of plurality suffix. Translator's note]

(54) [TITLE OF THE INVENTION]
DRYING METHOD OF COATING FILM, AND DEVICE OF THE SAME
[Tofumaku no kanso hoho oyobi sochi]

(57) [ABSTREACT]
[OBJECT]
According to drying of a coating film surface that is formed by coating various liquid-form compositions on a continuously traveling band-form flexible support body, it controls drying unevenness and allows drying with a good level of efficiency.

[MEANS OF SETTLEMENT]
A dryer (18) that condensates and collects a solvent within a coating solution was installed at a coating surface side of a traveling position in a manner immediately after the coating of various liquid-form compositions on a continuously traveling band-form flexible support body (12) through means of coating (16); and means of circulation drying (20) was installed at the traveling position after said dryer (18) to dry said coating film.



[CLAIMS]

[CLAIM ITEM 1]

According to a drying method of a coating film that is made to dry a coating film that is coated through means of coating of a coating solution on a traveling band-form flexible support body, the drying method of a coating film is characterized by the fact that a dryer that condensates and collects solvent in a coating solution is installed at a coating surface side of a traveling position in a manner immediately after the coating, and at the same time, means of circulation drying is installed at the traveling position after said dryer to dry said coating film.

[CLAIM ITEM 2]

The drying method of a coating film in accordance with the claim item 1,wherein at the least 3 % by mass of organic solvent is contained in said coating solution.

[CLAIM ITEM 3]

The drying method of a coating film in accordance with the claim item 1 or 2, wherein distance of said means of coating and said dryer is at the most 5 m.

[CLAIM ITEM 4]

The drying method of a coating film in accordance with the claim item, 1,2 or 3 wherein distance of said means of coating and said dryer is at the most 0.7 m.

[CLAIM ITEM 5]

The drying method of a coating film in accordance with the claim item 1,2,3 or 4, wherein traveling speed of said band-form flexible support body is such speed that band-form flexible support body reaches said dryer within 20 seconds after coating by said means of coating.

[CLAIM ITEM 6]

The drying method of a coating film in accordance with any claim items 1 ~ 5m wherein thickness of said coating film is 0.001 – 0.08 mm.

[CLAIM ITEM 7]

The drying method of a coating film in accordance with any claim items 1 ~ 6, wherein traveling speed of said band-form flexible support body is 1 ~ 100 m/minute.

[CLAIM ITEM 8]

The drying method of a coating film in accordance with any claim items 1 ~ 7, wherein said dryer condensates and collect at the least 10% of solvent in a coating solution.

[CLAIM ITEM 9]

The drying method of a coating film in accordance with any claim items 1~ 8, wherein means of cooling is installed on said dryer.

[CLAIM ITEM 10]
The drying method of a coating film in accordance with any claim items 1~ 9, wherein means of heating is installed at opposite to said dryer in such manner of scissoring said band-form flexible support body.

[CLAIM ITEM 11]
The drying method of a coating film in accordance with claim item 10, wherein heat roll is used for said means of heating.

[CLAIM ITEM 12]
The drying method of a coating film in accordance with claim item 10, wherein infrared ray heater is used as said means of heating.

[CLAIM ITEM 13]
The drying method of a coating film in accordance with any claim items 1 ~ 12, wherein distance of a surface of said coating film and a surface of said dryer is 0.01 – 200 mm.

[CLAIM ITEM 14]
According to a drying device for a coating film that dries a coating film that is coated that is installed at an after stage that follows means of coating that coats coating solution on a traveling band-form flexible support body, the drying device for a coating film is characterized by the fact that has a dryer that condensates and collect a solvent in a coating solution and is installed at a coating surface side of a traveling position in a manner immediately after the coating, and means of circulation drying that dries said coating film and is installed at the traveling position after said dryer.

[DETAILED EXPLANATION OF THE INVENTION]
[0001]
[TECHNICAL FIELDS OF THIS INVENTION]
This invention relates to a drying method of a coating film and device of the same; and in particular, it relates to the drying method that dries long and wide coating film surface that is formed through coating of various liquid-form compositions on a continuously traveling band-form flexible support body, and the device of the same.

[0002]
This technology may be utilized for undercoating of solvent on film sheets with optical functionality such as optical compensation sheets and the like, and films for photosensitive materials in addition to manufacturing of photosensitive materials for thermal development, functional films including particles with micro-structure such as nano-level particles and the like, photographic films, photographic papers, magnetic recording tapes, adhesive tapes, pressure-sensitive recording papers, offset printing materials, or batteries and the like.

[0003]
[PRIOR ART]
Regarding a drying method and device that dries long and wide coating film surface that is formed through coating of various liquid-form compositions on a continuously traveling band-form flexible support body, a coating method that is designed to dry by supporting a non-coated side with a roll and blowing wind [air] from an air nozzle on the coated-surface side as well as an air-floating drying method of a non-contact type that blows wind [air] from an air nozzle onto both coated surface as well as a non-coated surface to dry in a state that a support body is suspended , in other words, in a state that support body does not come in contact with a roll and the like are cited in the "Coating and Drying Defects" (Wiley-Interscience, John Wiley &:Sons, Inc.) authored by E.B.Gutoff and E.D. Cohen. According to this non-contact type drying method, a drying method that uses a string-coiled type dryer that is disclosed in the post-examined Japanese patent publication Sho 48 [1973]-42903 may be mentioned as a method that is capable of utilizing a space with good efficiency in addition to drying with good efficiency.

[0004]
Regarding these ordinary methods that is designed to dry by blowing wind [air] (these will be hereafter referred to as circulation drying method), drying is conducted by blowing wind [air] of which humidity is adjusted onto a coated surface to evaporate the solvent that is included in the coated surface. Although these ordinary drying methods are excellent in drying efficiency, because it applies wind [air] to the coated surface either directly or through a porous plate or an evener plate and the like, thickness of the coating layer becomes non-uniform causing unevenness due to disturbance that occurs on the coated surface caused by said wind [air], or evaporation speed of the solvent on the coated surface may become non-uniform due to convection current to consequently cause a so-called orange peel (make reference to "Coating Engineering" by Yuji OZAKI, pp. 293 ~ 294, Asakura Books, 1971) presenting a problem of not possible attainment of uniform coating layer.

[0005]
In particular, occurrence of such unevenness is prominent when organic solvents are included in the coating solution. The reason for this is that during initial period of drying shows a state that includes sufficient level of organic solvent in the coating film, and when distribution by evaporation of the organic solvent occurs in this stage, distribution of temperature as well as distribution of surface tension occur on the coating film surface to result in occurrence of flow motion such as so-called Marangoni convection and the like within such coating film surface. Occurrence of such unevenness invites critical coating defects.

[0006]
When liquid crystal is included within a coating film, problems of not only above-explained uneven coating, but also, slippage on the orientation of liquid crystal on the coating film surface caused by blown wind [air] have been also pointed out.

[0007]
As a method that solves these problem points, a structure that arranges a dryer for drying immediately after coating is disclosed in the Japanese patent application laid-open Tokkai 2001-170547 publication. According to this, it discloses a method that controls occurrence of unevenness in such ways that a drier for drying is divided, and while blowing wind [air] to this divided portion from one side end of the support body in a width-wise direction to the other side end. According to the Japanese patent application of Kokai Hei 9 [1995]-73016 publication, a method that installs a metal mesh in the place of dividing a dryer for drying is disclosed based on the same purpose.

[0008]
In addition, according to the Japanese patent laid-open Tokkai 2001-170547 publication, it discloses a method that increases viscosity of a coating solution either through increase of density of the coating solution or addition of a tackifier to the coating solution to control flow motion by wind [air] for drying on the coating film surface that is immediately after the coating, or a method that prevents from occurrence of unevenness through a leveling effect even when flow motion may occur due to the wind [air] for drying on the coating film surface immediately after coating.

[0009]
However, according to the methods disclosed in the publication of the Japanese patent laid-open Tokkai 2001-170547 or Kokai [laid-open] Hei 9[1995]-73016, although they may display an effect in controlling on in-flow of non-uniform wind from outside of the dryer for drying, when an attempt is made to control wind [air] velocity so not to disturb the coating film surface, it is necessary to significantly lower this wind [air] velocity. As a result, drying speed declines significantly, and it is necessary to lengthen the length of the dryer for drying to countermeasure against this. And therefore, coating efficiency worsens. Furthermore, it is difficult to totally eliminate the affect of wind even after such attempts.

[0010]
In addition, according to the method that tackifies coating solution or uses solution with high boiling point, as disclosed in the Japanese patent laid-open Tokkai 2001-170547 publication, it causes non-aptitude for a high speed coating or increase in drying time to present problems of extremely worsened production efficiency.

[0011]
As explained above, according to the circulation drying method, or in particular, circulation drying method when involving organic solvents in the coating solution, as it invites unevenness on drying of coating surface at initial period of drying, methods designed to dry by not blowing wind [air] are disclosed in the GB1401041, US5168639, or US5694701 and the like. That is to say, a method that dries after evaporation and collection of solvent in a coating solution without blowing wind [air] is disclosed in the GB1401041. This method refers to the method that carries out drying through arrangement of an inlet and an outlet of a support body at top part of a casing, and promotes evaporation of solvent from the coating surface through heating a non-coating surface within a casing to condensate said solvent by a method that forms dewdrops on the condensation plate that is installed at the coating surface side and collects solvent.

[0012]
In addition, US5168639 discloses a method that collects solvent at top part of support body that is made to travel in a horizontal manner through use of a drum. Furthermore, according to the US5694701, an improved method of lay out [structure] of the US5168639 is disclosed.

[0013]
[SUBJECTS SOLVED BY THIS INVENTION]
However, according to the GB1401401, as inlet and outlet of the support body is limited to the top part of the casing, it places significant restrictions on the lay out of the device; and it is difficult to combine this in an existing coating process. In addition, according to the example that is illustrated in the Fig. 5, as it is necessary to allocate a greater than set distance before entering a collection dryer after coating or to reverse the base prior to entering the collection dryer, it is difficult to control unevenness that occurs immediately after coating with a level of good efficiency.

[0014]
According to the US5168639, it is difficult to control the drying speed uniformly over an entire region within a casing because distance from the coating surface to condensation and solvent collection varies by the coating direction; and in addition, because distance of coating surface and condensation/cooling drum at nearby inlet and outlet of the casing become unnecessarily far apart to result in another type of coating unevenness caused by occurrence of spontaneous convection.

[0015]
According to the improved method of lay out [structure] that is disclosed in the US5168639, it is difficult to form a structure where distance from the coating device to condensation/collection of the solvent can be made closer, and it has been regarded insufficient as a countermeasure against coating unevenness.

[0016]
In addition, according to above-explained 3 types of prior art, although method of collection of the solvent is described, there is no specific description on the method of control method of occurrence on coating unevenness immediately after coating.

[0017]
Similarly, according to the method that is designed to condensate/collect the solvent and to dry the coating film as in the case of above-explained 3 types of prior art, drying efficiency declines significantly compared to that of circulation drying. Above all, according to above-explained prior art, there is no description on the improved method and the like that can allow drying of a coating film with good level of efficiency over entire drying system.

[0018]
This invention was done based on such circumstance; and according to a long and wide coating film surface that is formed by coating various liquid-form compositions on a continuously traveling band-form flexible support body, its purpose is to offer a drying method of a coating film that can control drying uevenness that occurs immediately after coating and provides drying with good efficiency, and a device of the same.

[0019]
[MEASURES USED TO SOLVE THE SUBJECTS]
According to a drying method of the coating film that dries coating film that is coated through means of coating of coating solution on a traveling band-form flexible support body, this invention attains said purpose through such characteristics as installations of a dryer that condensates/collects the solvent in a coating solution at a coating surface side of traveling position in a manner immediately after the coating, and at the same time, means of circulation drying at the traveling position after said dryer.

[0020]
According to this invention, in the case of method that dries long and wide coating film surface that is formed through coating of various liquid-form compositions on a continuously traveling band-form flexible support body, a dryer that condensates/collects the solvent in coating solution is installed at a coating surface side of traveling position in a manner immediately after that means of coating, and a circulation drying device is installed after that dryer to dry said coating film to enable to control drying unevenness that tends to occur immediately after coating with possible drying with good efficiency.

[0021]
In particular, the effects remain significantly large in such case when an organic solvent[s] is included in the coating solution, or when all the solvents in the coating solution are composed of organic solvents.

[0022]
Furthermore, this invention is characterized by the fact that said coating solution includes at the least 3 percent by mass organic solvent. It is possible to control drying unevenness that occurs immediately after coating and is possible to dry with a good level of efficiency through use of this invention even in this case.

[0023]
In addition, regarding organic solvents, they refer to organic compounds showing properties of dissolving substances of which examples include followings: aromatic hydrocarbons such as toluene, xylene, or styrene and the like; chlorinated aromatic hydrocarbons such as chlorbenzene, or ortho-dichlorobenzene, and the like; chlorinated aliphatic hydrocarbons including methane derivatives such as monochlormethane and the like; or ethane derivatives such as monochlorethane and the like, alcohols such as isopropyl alcohol, or isobutyl alcohol and the like; esters such as methyl acetate or ethyl acetate and the like; ethers such as ethyl ether or 1,4-dioxane and the like; ketones such as acetone or methyl ethyl ketone and the like; glycol ethers such as ethylene glycol monomethyl ether and the like; alicyclic hydrocarbons such as cyclohexane and the like; aliphatic hydrocarbons such as normal hexane and the like; and mixture of aliphatic or aromatic hydrocarbons.

[0024]
[ENFORCEMENT FORMATS OF THIS INVENTION]
Preferred enforcement formats of the drying method of a coating method and device of the same relating to this invention are explained in details below with attached Figures.

[0025]
Figure 1 illustrates a schematic drawing of one example of coating/drying line (10) that is combined with a drying device to which this invention's drying method of a coating film and device of the same are applied.

[0026]
As illustrated in the Figure, coating/drying line (10) is mainly formed of a feed device (14) that feeds band-form flexible support body (12) that is coiled in a roll form, a dryer (18) that condensates/collects the solvent in coating solution of the coating film that is coated and formed on the band-form flexible support body (12), means of circulation drying (20) that dries said coating film, a take up device (24) that takes up product that is manufactured through coating/drying, and multiple numbers of guide rollers (22), (22), (22) ..... that forms transport passage where said band-form flexible support body (12) travels.

[0027]
As the band-form flexible support body (12), resin films such as polyethylene or PET (polyethylene terephthalate) and the like, and papers, or metal foils and the like may be used.

[0028]
Regarding means of coating (16), various methods may be used. For instance, slot die coater, wire bar coater, roll coater, gravure coater, slide hopper coating method, or curtain coating method and the like may be used.

[0029]
Furthermore, regarding means of coating (16), it may be structured in such manner so the coating plane [surface] faces top side against horizontal direction as illustrated in the Figure 1 and Figure 2, or it may be structured to face down side against horizontal direction. In addition, it may be also structured to show an incline against horizontal direction.

[0030]
As illustrated in the Figure 3, it is possible to install a dust proofing equipment (20) at the stage prior to means of coating (16), or to provide a pre-treatment and the like to the surface of band-form flexible support body. In the case of optical films and the like that seek high quality with hardly any dust, it is possible to obtain coated and dried film showing high quality through utilizing these means at the same time.

[0031]
Regarding dryer (18), it is composed of a condensation plate[s] (30) that is of a plate-form member and is arranged in an almost parallel manner to the band-form flexible support body (12) with prescribed distance, and side plate[s] and the like that is installed vertically downward from the front and back sides of the condensation plate (30). It is structured so condensation plate (30) would condensate and collect evaporated solvent at the time when solvent in a coating solution of the coating film evaporates.

[0032]
Regarding the material of the surface of condensation plate (30) that is designed to condensate solvent, it may be of metals, plastics, or wood materials and the like and no particular limitations are placed; and when organic solvents are included in the coating solution, it is recommended to use such material that is durable against that organic solvent or to apply a coating on that surface.

[0033]
Regarding means to collect solvent that is condensed on the condensation plate (30) in the dryer (18), for instance, it may be done in such way through arrangement of a groove on a condensation surface of the condensation plate (30) to collect the solvent by utilizing a capillary force. Direction of the groove may be in the traveling direction of the band-form flexible support body (12), or it may be in the orthogonal direction to that. When condensation plate (30) is tilted, it is all right to arrange a groove in the direction that is easy to collect the solvent.

[0034]
According to an example that is illustrated in the Figure 4, a wooden bucket (30a) is placed to collect condensed solvent at the bottom right edge of the condensation plate (30); and solvent is collected via wooden bucket (30a).

[0035]
Besides use of condensation plate (30) that is of a plate-form member, it is all right to use a structure showing the same function, for instance, components using a porous plate, mesh, slatted drain-board, or roll and the like on the dryer (18). In addition, it is all right to jointly use a collection device as disclosed in the US5694701.

[0036]
It is preferable when dryer is placed as close as possible to means of coating (16) in order to prevent from coating unevenness on the coating film caused by spontaneous convection immediately after coating of the coating solution. More specifically, it is recommended to place the inlet of the drier (18) at the position that is within 5 m from the means of coating (16), or more preferably, to place this at the position that is within 2 m, and most preferably, to place this at the position that is within 0.7 m.

[0037]
Based on the same reason, it is preferable when traveling speed of the band-form flexible support body (12) is as such that said band-form flexible support body (12) reaches the drier (18) within 20 seconds after coating by the means of coating (16).

[0038]
Regarding coating weight of the coating solution and coating film thickness, unevenness occurs naturally easier when they are large because of easy occurrence of flow motion within a coating film; however, according to this invention, sufficient effect can be attained even when coating weight and coating film thickness happen to be large. It is possible to carry out efficient drying with no unevenness when thickness of the coating film is 0.001 ~ 0.08 mm.

[0039]
When travel speed of the band-form flexible support body (12) happens to be too large [fast], bordering layer nearby coating film becomes disturbed by accompanied wind [air] and shows ill affect on the coating film. And therefore, it is recommended to set the traveling speed of the and-form flexible support body (12) to 1 ~ 100 m/minute.

[0040]
As unevenness of coating film tends to occur particularly during initial period of drying, it is recommended to make the dryer (18) to condensate/collect at the least 10% of solvent in the coating solution and drying remaining coating solution through means of circulation drying (20). Decision may be made on the rate of % of condensation/collection of the solvent in the coating solution in overall manner by giving consideration on affect on drying unevenness on the coating film, or productivity and the like.

[0041]
It is recommended to heat band-form flexible support body (12) and/or coating film, or to cool condensation plate (30), or to adapt both means in order to promote evaporation/condensation of the solvent in the coating solution. For instance, means of cooling may be installed on the drier, and means of heating may be installed at the opposite side of the dryer (18) in a manner of scissoring the band-form flexible support body (12).

[0042]
In any case, it is preferable when temperature management is provided in order to control drying speed of the coating film. It is necessary that the condensation plate (30) is equipped with temperature control and when there is a need for cooling, equipment for purpose of cooling must be installed. For this cooling, heat-exchanger type with water cooling using a coolant and the like, or air cooling that uses wind [air], a method that uses electricity, for instance, a method that uses Peltier element and the like may be used.

[0043]
When it is desired to heat band-form flexible support body (12) or coating film, or both, a heater may be placed at the side opposite to the coating film for purpose of heating. In addition, it is also possible to heat through placement of a transport roll (heating roll) of which temperature may be raised. Besides these, it is all right to heat through use of infrared heater or means of heating that uses microwave and the like.

[0044]
When deciding the temperature of band-form flexible support body (12), coating film, or condensation plate (30), caution must be paid so not to allow formation of dewdrops of the evaporated solvent at the location other than the condensation plate (30), for instance, on the surface of transport roll and the like. And therefore, it is possible to avoid this type of formation of dewdrops by raising the temperature of the portions other than condensation plate (30) to higher than that of the condensation plate (30).

[0045]
Regarding the distance (gap) of a surface of coating film and surface of condensation plate (30) of the dryer (18), it is necessary to adjust to appropriate distance by giving consideration over prescribed drying speed of the coating film. When distance is made short, drying speed would increase, but while on the other hand, it is easily affected by the drying precision that is set. On the one hand, when distance is increased, it not only causes significant decline in drying speed, but also spontaneous convention occurs by heat to trigger drying unevenness. Distance of a surface of coating film and surface of condensation plate (30) of the drier (18) is preferable when it is 0.1 ~ 200 mm, or more preferably, 0.5 ~ 100 mm.

[0046]
In addition, it is also possible to use such structure of the drier (18) having multiple numbers of guide rollers (22), (22) ... at opposite side of the condensation plate (30) in a manner of scissoring the band-form flexible support body (12), or it is all right to use a structure that is illustrated in the Figure 1(a) and Figure 2(a) that does not use arrangement of guide rollers (22), (22).....

[0047]
The dryer (18) does not necessarily need to be in a straight-line form as illustrated in the Figure 1; and for instance, it may be of the dryer (18) of an arc shape as illustrated in the Figure 2. In addition, it is all right to arrange a large drum that has an installation of the dryer.

[0048]
Furthermore, according to the example illustrated in the Figure 2, collection efficiency of the solvent is improved by approaching an arc-shaped dryer (18) to means of coating (16).

[0049]
Regarding means of circulation drying (20), following drying devices that are used as prior art may be used: roller transport dryer method that supports non-coated surface side with a roll and blows wind [air] from an air nozzle onto coated surface side to dry; a non-contact type air floating dryer method that dries while support body remains afloat by blowing wind from air nozzle on coated and non-coated planes, in other words, method that dries without allowing support body to come in contact a roll and the like; a string coiled type drying method that is one type of non-contact type drying method and utilizes space efficiently and provided efficient drying. No matter what drying device with what type of methods, they are common on the point that supplies dried air to a surface of coating film to dry that coating film.

[0050]
Regarding feed device (14), guide roller (22), or take up device (24) and the like that are used for the coating/drying line (10) that is combined in the drying device to which this invention's drying method of a coating film and device of the same are applied, they are of commonly used members, and explanation on those are omitted.

[0051]
According to this invention's drying device of a coating film explained in detail above, it is possible to control unevenness that occurs on the coating film immediately after coating while drying said coating film uniformly with good efficiency. In addition, flexible design on the means of prescribing coating solution is possible without requiring a significant changes on the lay out of coating/drying processes by not being restricted by the physical properties of coating solution or types of solvents and the like.

[0052]
That is to say, for instance, this invention's device and its same format may be implemented by simply adding installation of a dryer that condensates and collects the solvent between a coating part of the coating/drying device that includes existing circulation drying device. As a result, it is possible to modify the device at less cost.

[0053]
In addition, according to this invention's drying device of a coating film, it displays effect on energy saving as well as cost reduction. In other words, of the evaporation gas that generates in the coating/drying line, solvent other than water cannot be discharged to atmosphere as it is, and it is necessary to liquefy and collect this evaporation gas, and solvent collection equipment is required. However, because solvent can be directly collected in a liquid state in the dryer that condensates and collects part of coating solution, it is possible to reduce load placed on the solvent gas collection equipment.

[0054]
Furthermore, according to this invention's drying device of a coating film, it was found to display following effects that were not expected because of possible very uniform drying at initial period of drying: that is to say, because conventional circulation drying device is not capable of controlling the effects that disturb flow motion of the coating film totally, flow motion occurs in the coating film. However, it is possible to prevent this flow motion by using this invention's device, and furthermore, it can form the structure of particle or polymer network as very fine, and above all, it can form this uniformly.

[0055]
Through above description, it becomes not only possible to simply dry a coating film uniformly, but also it will lead to the new added function in a case of, for instance, optical films due to possible formation of fine structure of coating film.

[0056]
In addition, this invention's drying device of a coating film is much suited for drying of functional films including, for instance, nano-level particles and the like.

[0057]
This invention's drying device of a coating film provides the same effects even when it is used for the coating solution with dissolved or dispersed solids of polymer or particles and the like. Or rather, occurrence of drying unevenness shows significant affect on the dispersion/distribution of particles in the coating film in the system that includes particles. And therefore, it is recommended to use this system for said system.

[0058]
[EXAMPLES]
[EXAMPLE 1]
A dryer (18) that condensates/collects solvent in a coating solution was installed on a drying process of drying layer in the manufacturing line of optical compensation sheets illustrated in the Figure 3 to study the structure of the dryer that is suited for manufacturing of optical compensation sheets as well as condensation/collection conditions of the solvent.

[0059]
As illustrated in the Figure 3, manufacturing line of optical compensation sheets is carried out, for instance, through following processes:

1) Feed process (50) of a transparent film (12);
2) Process that forms (52) resin layer for purpose of forming an oriented film that is prepared by coating/drying a coating solution that includes resin for purpose of forming an oriented film on a surface of transparent film;
3) Lapping process (54) that forms oriented film on a transparent film on which surface, resin layer for purpose of forming an oriented film is formed through a lapping treatment that is applied on the surface of the resin layer;
4) Coating process (16) of discotic liquid crystal on an oriented film through a coating solution that includes discotic liquid crystal;
5) Drying process (18) that dries said coating film to evaporate solvent within said coating film;
6) Liquid crystal layer forming process (58) that forms liquid crystal layer of discotic nematic [disconematic] phase by heating said coating film up to the temperature that forms discotic nematic [disconematic] phase;
7) Process (60) to solidify said liquid crystal layer (in other words, either to solidify by quenching after forming a liquid crystal layer, or crosslinking through irradiation of light (or heating) when discotic liquid crystal compound that includes cross-linking functional radical is used);
8) Process (24) to take up transparent film on which said oriented film and liquid crystal layer are formed.

[[0060]
Furthermore, according to the Figure 3, (62) shows a drying zone, (64) shows an inspection device, (66) shows a protective film, (68) shows a lamination machine, and (70) shows a dust-proofing equipment respectively.

[0061]
Regarding manufacturing method of optical compensation sheets, it was conducted continuously from start of feed process of a long transparent film to the process that takes up thus given optical compensation sheets as illustrated in the Figure 3. A long chain alkyl modified poval (MP-203, made by Kuraray K.K.) solution was coated at 5 weight % on one side of a long film of triacetyl cellulose (Fujitac [transliteration] made by Fuji Photo Film K.K., thickness: 100 μm, width: 500 mm); and after it was dried for 4 minutes at 90°C, it was subjected to a lapping treatment to form a resin layer for forming an oriented film with 2.0 μm film thickness. Transport speed of the film was 20 m/minute.

[0062]
Regarding above-explained triacetyl cellulose film, when refractive index of two directions that intersect on in-plane of the film are identified as nx, ny, and refractive index in thickness direction is identified as nz, and film thickness is identified as d, it was (nx-ny) x d = 16 nm, {(nx-ny)/2-nz} x d =75nm. In addition, above-explained resin layer for forming of oriented film was conducted by using a coating/drying device.

[0063]
Then, resin layer surface of thus given film having a resin layer was subjected to a lapping treatment while this was transported continuously at 20 m/minute. Lamming treatment was conducted at 300-rpm rotation rate of lapping roller, and then, thus given oriented film was subjected to a dust removal.

[0064]
Then, while transporting thus given film with an oriented film continuously at 20 m/minute speed, it was coated with 10 weight % methyl ethyl ketone solution (coating solution) that is a mixture prepared by adding 1 weight % of photo polymerization initiator (Irgacure 907 made by Japan Ciba Geigy K.K.) to a mixture of 4:1 weight ratio discotic compound TE-8 (3) and TE-8 (5) on the oriented film by using a wire bar coater at 20 m/minute coating speed and 5cc/m^2 coating weight; and then, it was passed through a drying and heating zone. Wind was blown into the drying zone, and heating zone was adjusted to 130°C. It was designed to enter drying zone 3 seconds after coating, and to enter heating zone 3 seconds after that. It was also designed to pass through heating zone in about 3 minutes.

[0065]
Then, the film on which said oriented film and liquid crystal layer were coated was irradiated with UV ray from and YV ray lamp on its liquid crystal layer while being transported continuously at 20 m/minute. That is to say, the film that passed through above-explained heating zone was irradiated with UV ray of 600 mW illuminance by using a UV ray irradiation device (UV ray lamp: 160 W/cm output, light emission length 1.6 m) for 4 seconds to crosslink liquid crystal layer.

[0066]
Tests were conducted on above-explained processes based on 6 types of conditions. Conditions and results are described below.

[0067]
(TEST 1)
Heater temperature was set at 85°C, and condensation plate temperature was set at 25°C. Length of the dryer (18) was set as 3m, and inlet was arranged in such a way so the inlet would be at the position that is 500 mm from the means of coating (16). Distance of a surface of coating film and surface of condensation plate (30) of the dryer (18) was set to be 1 mm. Traveling speed of the band-form flexible support body (12) was set to be 20 m /minute. After treatment by the dryer (18), it was dried through means of circulation drying.

[0068]
Consequently, no problems on the qualities of coating film were noted.

[0069]
(TEST 2)
Heater temperature was set at 60°C, and regarding dryer (18), it was structured as 3 pieces of block shapes showing 1.5 m length were lined (condensation plate (30) was divided into 3 zones); and it was arranged in such way so the inlet would be positioned at 1 m from means of coating (16). In addition, condensation plate temperature of these 3 condensation plates (30) was set to be 25°C, 20°C, and 15°C respectively in the direction toward down flow side of the traveling direction. Distance of a surface of coating film and surface of condensation plate (30) of the dryer (18) was set to be 1.5 mm. Traveling speed of the bend-form flexible support body (12) was set to be 20 m/minute. After treatment by the dryer (18), it was dried through means of circulation drying.

[0070]
Consequently, no problems on the qualities of coating film were noted.

[0071]
(TEST 3, COMPARATIVE EXAMPLE)
Coating was dried only by means of circulation drying without arrangement of the dryer (18). Other conditions were identical to those of the test 1.

[0072]
Consequently, drying unevenness occurred on the coating film, and in addition, orientation defects also occurred.

[0073]
(EXAMPLE 2)
According to the drying process after primer coating on the manufacturing line of photosensitive cellulose acetate films, comparison was made on a case when this invention's dryer that condensates/collects solvent in the coating solution was installed, and the case when conventional dryer of circulation drying type was installed.

[0074]
According to the manufacturing line that uses this invention's dryer illustrated in the Figure 4, cellulose acetate dope is flown onto a RYUEN [transliteration hereafter, this term could not be found in any of the dictionaries (at the least 9 dictionaries), it literally means flow and extend or draw, translator's note] die to a RYUEN drum surface, and the film thus formed is peeled off with a peel-off roller, and is dried with hot air while traveling between rolls of pre-drying process.

[0075]
Then, this was coated with a photographic photosensitive material primer, and was further dried with a dryer (18). At the point when residual solvent reached at the most about 10%, it was guided to a width regulating device (not illustrated in the Figures) to be drawn by 2 ~ 6% in width direction, and after it was quenched in strained state, it was taken up.

[0076]
The condensation plate (30) of the dryer (18) was divided into two zones. In addition, two condensation plates (30) were arranged with such angle of incline so both of them would be apart from the coating film at down flow side of the traveling direction. Distance of a surface of coating film and surface of condensation plates (30) of the dryer (18) was set to be 0.8 mm at inlet side of the condensation plate (30) at upper flow side ant 2 mm at outlet side in the direction toward down flow side of the traveling direction, and 0.8 mm at inlet side and 2 mm at outlet side of the condensation plate (30) of down flow side.

[0077]
In addition, length of condensation plates (30) of upper flow side was set as 2m, and length of condensation plates (30) of down flow side was set as 4m. Setting temperature of the condensation plates (30) was all at 15°C.

[0078]
Surface properties of thus manufactured product were good.

[0079]
According to the manufacturing line that uses conventional circulation drying type dryer that is illustrated in the Figure 5, device for primer coating drying process is of a conventional circulation drying type dryer. The other portions of the manufacturing line are of the same structure as illustrated in the Figure 4, and further explanation is omitted.

[0080]
Surface properties of thus manufactured product showed defects with occurrence of drying unevenness at the time of primer coating.

[0081]
(EXAMPLE 3)
Comparison was made on the case of example when means of drying that is a combination of dryer for condensation/collection (front stage side) and means of circulation drying (back stage side) was installed to the drying process on manufacturing line of thermal development photosensitive material, and the case when only means of drying of a conventional circulation drying type was installed.

[0082]
A coating solution for thermal development photosensitive material that is coated on a band-form flexible support body was adjusted in the manner explained below.

[0083]
1) ADJUSTMENT OF SILVER HALIDE PARTICLES
22g of phthalated gelatin and 30 mg of potassium bromide were dissolved in 700 m liter water, and after PH was adjusted to 5 at 35°C temperature, 159 m liter aqueous solution containing 18.6g of silver nitrate and aqueous solution containing potassium bromide and potassium iodide at 92:8 mole ratio were added by taking 10 minutes through a control double jet method. Then, 476 m liter aqueous solution containing 55.4 g of silver nitrate and aqueous solution containing 10.5 μ mole/liter of secondary potassium iridium acid hexachloride and 1 mole/liter of potassium bromide were added by taking 30 minutes while maintaining 7.7 pAg using a control double jet method. Then, PH was lowered to desalt through a flocculation, and 0.11 g of phenoxy ethanol was added, and it was adjusted to PH 5.9, pAg 8.2 to prepare silver iodobromide particles (cubic particles showing iodine core content of 8 mole %, average size 0.05 μm, fluctuation coefficient of projection area 8%, and (100) plane percentage 90%).

[0084]
Thus given silver halide particles were raised to 60°C temperature, and 85 μ mole of sodium thiosulfite, 11 μ mole of 2,3,4,5,6 pentafluoro phenyl diphenyl phosphine selenide, 15 μ mole of tellurium compound, 3.6 μ mole of chloroauric acid, and 230 μ mole of thiocyanate were added based on 1 mole of silver; and after it was ripened for 120 minutes, it was quenched to 30°C to give a silver halide emulsion.

[0085]
2) ADJUSTMENT OF ORGANIC ACID SILVER EMULSION

13 g of stearic cid, 0.5 g of arachidic acid, 8.5 g of behenic acid, and 300 m liter of distilled water were mixed for 40 minutes at 90°C, and while it was vigorously stirred, 31.1 m liter of1N sodium hydroxide aqueous solution was added by taking 15 minutes, and then, it was raised to 30°C temperature. Then, 7 m liter of 1N phosphoric acid aqueous solution was added, and while it was vigorously stirred, 0.012 g of N-bromosuccinimide was added; and then, silver halide particles adjusted earlier were added to set the silver halide content to 2.5 m mole. Furthermore, 25 m liter of 1N silver nitrate aqueous solution was added by taking 25 minutes, and it was continued to be stirred for 90 minutes. Then, solids were filtered out with a suction filter, and solids were rinsed with water till electrical conductivity of thus filtered solution reached 30 μ S.Cm. 37 g of butyl acetate solution including 1.2 weight % of polyvinyl acetate was added to thus obtained solids; and it was stirred, and was left undisturbed after stirring was ceased to separate to oil layer [phase] and water layer [phase], and water layer was removed along with the salt included to give oil layer. Then, 20 g of 2.5 weight % 2-butanone of polyvinyl butylal solution were added to this oil layer and were stirred. Furthermore, 0.1 m mole of pyridium perbromide and 0.18 m mole of calcium bromide dehydrate along with 0.7 g of methanol were added, and then, 40g of 2-butanone and 7.8 g of polyvinyl butylal were added; and it was dispersed in a homogenizer to give organic acid salt emulsion (needle-form particles showing 0.04 μm average short diameter [transliteration] and 1 μm average long diameter [transliteration], and 30% fluctuation coefficient [note: above transliteration of short and long diameter may be also translated as minor and major, translator's note]).

[0086]
3) ADJUSTMENT OF COATING SOLUTION OF EMULSION LAYER

Each chemical shown below was added to organic acid silver salt given in the manner explained above in a manner so it would be the amount as described below per 1 mole of silver. Addition of the followings were made at 25°C while stirring, and was left undisturbed for 3 hours: 10 mg of sodium phenyl thiosulfonate, 68 mg of coloring matter 1, 30 mg of coloring matter 2, 2 g of 20mercapto-5-methyl benzoimidazole, 21,5 g of 4-chlorobenzophenone-2-carboxylic acid, 580 g of 2-betanone, and 220 g of dimethyl formamide. Then, followings were added while stirring: 8 g or 5-tribromomethyl sulfonyl-2-methyl thiadiazole, 6g of 2-tribromomethyl sulfonyl benzothiazole, 5g of 4,6-ditrichloromethyl-2-phenyltriazine, 2g of disulfide compound, 160g of 1,1-bis (2-hydroxy-3,5-dimethyl phenyl)-3,5,5 trimethyl hexane, 5g of tetrachlorophthalate, 1,1g of fluorine group surfactant, 590 g of 2-butanone, and 10 g of methyl isobutyl ketone.

[0087]
The coating solution for emulsion layer that was adjusted as explained above was coated on a polyethylene terephthalate support body with 175 μm (band-form flexible support body) that was tinted blue with a blue dye in such manner to provide 2.3 g/cm^2 silver. Then, after said coating, in the case of example, it was dried with a dryer (front stage side) that condensates/collects and means of circulation drying (back state side), and was irradiated with UV ray to give a thermal development photosensitive material. On the one hand, in the case of comparative example, coating film was dried only with a circulation drying type dryer, and it was irradiated with UV ray to give a thermal development photosensitive material.

[0088]
Surface properties of the product manufactured by the method described in the example were good. On the one hand, surface properties of the product manufactured by the method described in the comparative example showed defects by being affected with uneven wind.

[0089]
(EXAMPLE 4)
Comparison was made on a case of example in which means of drying that is a combination of condensation and collection dryer (front stage side) and means of circulation drying (back stage side) that was installed on the drying process of manufacturing line of hard coating film, and a case of comparative example in which only the means of drying by a conventional circulation drying type was installed.

[0090]
Coating solution for hard coating that is coated on a band-form flexible support body was adjusted in the manner explained below.

1) ADJUSTMENT OF INORGANIC PARTICLE DISPERSED SOLUTION (M-1)
Following reagents were compounded at the compounding rate shown below in a ceramic-coated container to adjust a solution mixture:

[0091]

- Cyclohexanc – 337g
- Methacrylate containing phosphoric acid radicals (PM-2: made by Nihon Kayaku K.K.) – 31g
- Alumina (AKP-G015: made by Sumitomo Kagaku Kogyo K.K., particle size 15 nm) – 92g

A solution mixture given was finely dispersed for 10 hours in a sand mill (1/4 G sand mill). 1400 g of zirconia beads with 1 mm Φ were used as medium. After dispersion, zirconia beads were separated to give a dispersed solution of surface modified inorganic particles (M-1).

[0092]
2) ADJUSTMENT OF COATING SOLUTION FOR ACTIVE ENERGY BEAN CURABLE LAYER

To 116g of 43 weight % cyclohexanone dispersed solution (M-1) of surface treated alumina fine particles, 97g of methanol and 163 g of isopropanol were added; and in addition, 163 g of methyl isobutyl ketone was added. To this mixture solution, 200g of mixture (DPHA made by Nihon Kagaku K.K.) of dipentaerithritol penta acrylate and dipentaerithritol hexa acrylate were added and dissolved. Furthermore, 7.5g of photo polymerization initiator (Irgacure 184 made by Ciba Geigy K.K.) was added and dissolved. After stirring this mixture for 30 minutes, it was filtered with a 1 μm pore diameter filter made of polypropylene to adjust a coating solution for active energy beam curable layer.

[0093]
3) [note: there is no title to this 30, translator's note]

After glow discharge treating a band-form flexible support body (base film), it was coated with active energy beam curable layer coating solution that includes alumina to give 8 μm dry film thickness by means of wire bar coating. Then, after said coating, in the case of example, it was dried with a condensation and collection dryer (front stage side) and means of circulation drying (back stage side), and it was UV ray irradiated to give a cured layer. On the one hand, in the case of comparative example, after coating film was dried only with a circulation drying type dryer, it was UV ray irradiated to give a cured layer.

[0094]
Then, comparison was made on a case of example in which means of drying that is of a combination of condensation and collection dryer (front stage side) and means of circulation drying (back stage side) that was installed on the drying process of manufacturing line of thick hard coating film, and a case of comparative example in which only the means of drying with conventional circulation drying type was installed.

[0095]
Coating solution for thick hard coating film that is coated on a band-form flexible support body was adjusted in the manner explained below.

[0096]
1) ADJUSTMENT OF COMPOUND THAT CONTAING RING-OPENING POLYMERIZABLE RADICALS (K-1)

Polymerization initiator added solution was adjusted by first stirring 275 m liter of methyl ethyl ketone (MEK) under nitrogen gas flow at 60°C for 1 hour, and adding total amount prepared by dissolving 0.5 g of polymerization initiator (V-65 made by Wako Junyaku K.K.) in 8.3 m liter MEK. Then, 50g of glycidyl methacrylate was dropped by taking 2 hours, and after completion of said dropping, polymerization initiator added solution that was adjusted beforehand was added to react for 2 hours. Then, reaction temperature was set at 80°C, and was reacted for 2 hours, and after completion of said reaction, it was cooled down to room temperature. Thus given reaction solution was dropped in 10 liter of hexane by taking 1 hour; and precipitates were dried at 35°C for 8 hours under reduced pressure to give compound that contains ring-opening polymerizable radicals (K-1).

[0097]
2) ADJUSTMENT OF CURABLE COMPOSITION

After dissolving 75 parts of trimethylol propane triacrylate (ethylenic unsaturated radical containing compound), 25 parts of ring-opening polymerizable radical containing compound (K-1) adjusted beforehand, radical polymerization initiator (Irgacure 184 made by Ciba Geigy K.K.), and cation polymerization initiator (UV1-6990 made by Union Carbide Japan K.K.) in 40 parts of mixture solution of methyl isobutyl ketone/methyl ethyl ketone (1/5), it was stirred for 30 minutes to give a curable composition. Furthermore, regarding polymerization initiator, addition of 2.9 weight % of each radical polymerization initiator and cation polymerization initiator based on total amount of ethylenic unsaturated radical containing compound and ring-opening polymerizable radical containing compound was made.

[0098]
3) [note: there is no title of this 3), translator's note]

Regarding a transparent band-form flexible support body (transparent base film), polyethylene terephthalate film with 188 μm thickness was used; and after this was subjected to a glow discharge treatment, curable composition that was adjusted as explained above was coated through a coating method of extrusion type. Then, after said coating, in a case of example, a thick hard coating film was obtained by first drying through a condensation and collection dryer (front stage side) and means of circulation drying (back stage side), it was UV ray irradiated, and was further heated for 10 minutes at 120°C. On the one hand, in the case of comparative example, after coating film was dried only with a circulation drying type dryer, it was UV ray irradiated and was further heated for 10 minutes at 120°C to give a thick hard coating film. Furthermore, drying was conducted based on such conditions as for 2 minutes at 120°C and UV ray irradiation of 750 mj/cm^2.

[0099]
Surface properties of the product manufactured by the method described in the examples were good. On the one hand, surface properties of the product manufactured by the method described in the comparative example were defective with occurrence of uneven thickness that can be possibly blamed on the affect of uneven wind [air].

[0100]
[EFFECTS OF THIS INVENTION]
According to this invention's drying method of a coating film and device of the same, it is possible to control drying unevenness that occurs immediately after coating on a long and wide coating film surface formed by coating various liquid-form compositions on a continuously traveling band-form flexible support body, and in addition, it is possible to dry said coating film uniformly with good level of efficiency.

[0101]
In addition, because it does not need to alter the lay out of coating and drying process as well as not being greatly restricted by physical properties or types of solvent in the coating solution, flexible design on means of coating solution prescription is possible. In addition, it displays effects such as energy saving as well as reduced cost.

[0102]
Furthermore, it is possible to prevent from fluid motion within a coating film to allow formation of very fine and above all uniform network structure of polymer as well as particles in the coating film that is formed during drying.

[BRIEF DESCRIPTION OF THE FIGURES]
[FIGURE 1]
It illustrates a schematic drawing of one example of coating/drying line combined with a drying device to which this invention's drying method of a coating film and device of the same are implemented.

[FIGURE 2]
It illustrates a schematic drawing of other example of coating/drying line combined with a drying device to which this invention's drying method of a coating film and device of the same are implemented.

[FIGURE 3]
It illustrates a schematic drawing of an example that uses drying device of a coating film of this invention for a manufacturing line of optical compensation sheets.

[FIGURE 4]
It illustrates a schematic drawing of an example that uses drying device of a coating film of this invention for a manufacturing line of photosensitive cellulose acetate films.

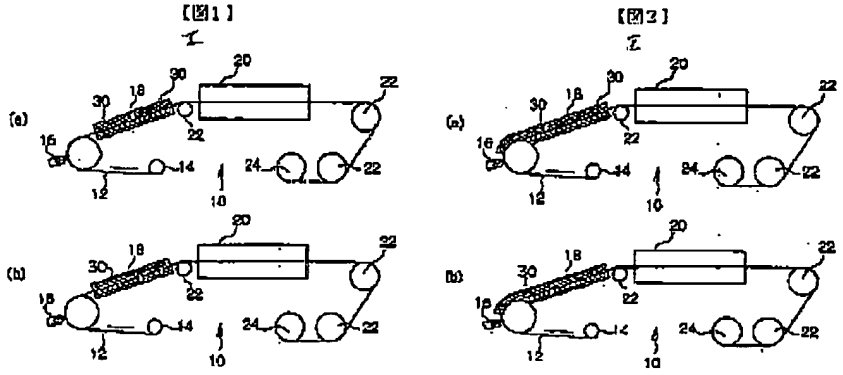
[FIGURE 5]
It illustrates a schematic drawing of an example that uses dryer of circulation drying type that is of a conventional example for a manufacturing line of photosensitive cellulose acetate films.

[DESCRIPTION OF CODES]
10: coating/drying line, 12: band-form flexible support body, 14: feed device, 16: means of coating, 18: dryer, 20: means of circulation drying, 22: guide roller, 24: take up device, 30: condensation plate

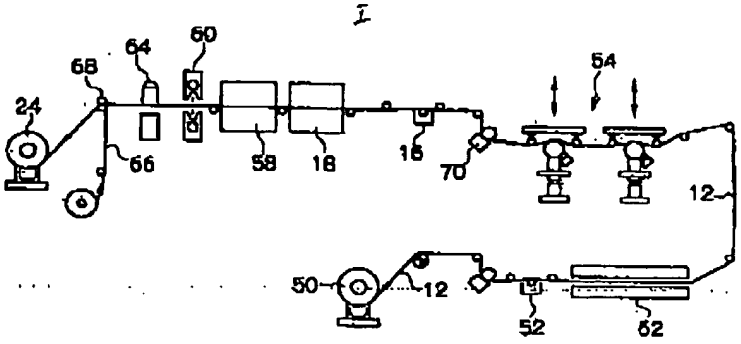
Translation requested by: Brian Szymanski, OIPC
Translation by: Mie N. Amtson, 512-331-7167

Figures 1 through 5

I: Figure, II: take up, III: post drying process, IV: RYUEN die, V: RYUEN part of drum, VI: peel off roller, VII: condensation/collection process, VIII: primer coating, IX: pre-drying process, X: primer coating drying process,



【図3】



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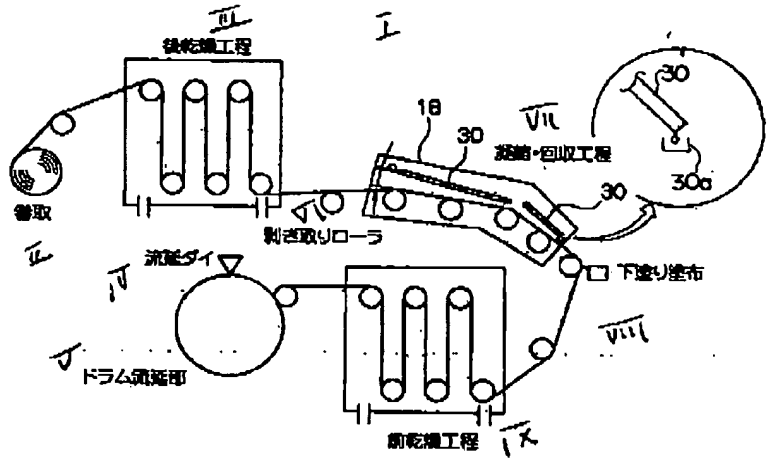

【図5】